LASERS

System Parameters

Efficiencies and power levels are approximately state-of-the-art (1990).[31]

Type	Wavelength (μm)	Efficiency	Power levels available (W)	
			Pulsed	CW
CO_2	10.6	0.01–0.02 (pulsed)	$> 2 \times 10^{13}$	$> 10^5$
CO	5	0.4	$> 10^9$	> 100
Holmium	2.06	0.03†–0.1‡	$> 10^7$	30
Iodine	1.315	0.003	$> 10^{12}$	–
Nd-glass, YAG	1.06	0.001–0.06† > 0.1‡	$\sim 10^{14}$ (ten-beam system)	1–10^3
*Color center	1–4	10^{-3}	$> 10^6$	1
*Vibronic (Ti Sapphire)	0.7–0.9	$> 0.1 \times \eta_p$	10^6	1–5
Ruby	0.6943	$< 10^{-3}$	10^{10}	1
He-Ne	0.6328	10^{-4}	–	1–50×10^{-3}
*Argon ion	0.45–0.60	10^{-3}	5×10^4	1–20
*OPO	0.4–9.0	$> 0.1 \times \eta_p$	10^6	1–5
N_2	0.3371	0.001–0.05	10^5–10^6	–
*Dye	0.3–1.1	10^{-3}	$> 10^6$	140
Kr-F	0.26	0.08	$> 10^9$	500
Xenon	0.175	0.02	$> 10^8$	–

*Tunable sources †lamp-driven ‡diode-driven

YAG stands for Yttrium–Aluminum Garnet and OPO for Optical Parametric Oscillator; η_p is pump laser efficiency.

Formulas

An e-m wave with $\mathbf{k} \parallel \mathbf{B}$ has an index of refraction given by

$$n_{\pm} = [1 - \omega_{pe}^{2}/\omega(\omega \mp \omega_{ce})]^{1/2},$$

where $\pm$ refers to the helicity. The rate of change of polarization angle θ as a function of displacement s (Faraday rotation) is given by

$$d\theta/ds = (k/2)(n_{-} - n_{+}) = 2.36 \times 10^{4} NBf^{-2}\,\mathrm{cm}^{-1},$$

where N is the electron number density, B is the field strength, and f is the wave frequency, all in cgs.

The quiver velocity of an electron in an e-m field of angular frequency ω is

$$v_0 = eE_{\mathrm{max}}/m\omega = 25.6 I^{1/2} \lambda_0\,\mathrm{cm\,sec}^{-1}$$

in terms of the laser flux $I = cE_{\mathrm{max}}^{2}/8\pi$, with I in watt/cm^2, laser wavelength λ_0 in μm. The ratio of quiver energy to thermal energy is

$$W_{\mathrm{qu}}/W_{\mathrm{th}} = m_e {v_0}^2/2kT = 1.81 \times 10^{-13} {\lambda_0}^2 I/T,$$

where T is given in eV. For example, if $I = 10^{15}\,\mathrm{W\,cm}^{-2}$, $\lambda_0 = 1\,\mu\mathrm{m}$, $T = 2\,\mathrm{keV}$, then $W_{\mathrm{qu}}/W_{\mathrm{th}} \approx 0.1$.

Pondermotive force:

$$\boldsymbol{\mathcal{F}} = N \nabla \langle E^2 \rangle / 8\pi N_c,$$

where

$$N_c = 1.1 \times 10^{21} {\lambda_0}^{-2} \mathrm{cm}^{-3}.$$

For uniform illumination of a lens with f-number F, the diameter d at focus (85% of the energy) and the depth of focus l (distance to first zero in intensity) are given by

$$d \approx 2.44 F \lambda \theta / \theta_{DL} \quad \text{and} \quad l \approx \pm 2F^2 \lambda \theta / \theta_{DL}.$$

Here θ is the beam divergence containing 85% of energy and θ_{DL} is the diffraction-limited divergence:

$$\theta_{DL} = 2.44 \lambda / b,$$

where b is the aperture. These formulas are modified for nonuniform (such as Gaussian) illumination of the lens or for pathological laser profiles.